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AKO AOTEAROA

RESIST

Updating and upgrading an earthquake design tool for architecture and civil engineering teachers and students

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AKO AOTEAROA
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TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI VICTORIA UNIVERSITY OF WELLINGTON

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Introduction

The goals of this project were to:

1. Update the RESIST software so it complies with the requirements of the most recent NZ Standard for earthquake design,
2. Enhance RESIST so that it is even more user-friendly and comprehensive in its seismic design capabilities, and
3. Make RESIST more accessible as a teaching and a design tool for staff and students. It is important that students who are designing buildings can undertake their own preliminary designs for wind and earthquake loads.

Background

RESIST facilitates preliminary designs of buildings against wind and earthquake loads. For over 20 years various versions of RESIST have empowered architecture students to design structures for their design projects. RESIST overcomes the powerlessness that students experience when needing to know how much and the size of structure required to resist lateral loads. The program enables them to very quickly get a feel for what structure is required in a given building, and to explore the various factors that affect the size of that structure, such as increased floor plan dimensions and weights of construction. Since students who use RESIST can design structural walls, moment frames and four different types of cross-braced frames, they become familiar with all principal lateral load resisting systems. Students are introduced to RESIST, where it is also used as a teaching tool, in a lecture. After this brief introduction, they are able to use the program in their own design projects. A huge benefit of the program is that it enables students to quickly explore many different structural solutions before arriving at the one that integrates best with their architectural design concept.

RESIST is unique internationally in that it enables users to design seismic resisting structures, like walls and beams and columns for buildings, without calculations. Users just need to make certain choices of design assumptions and RESIST does the rest.

For the last five to ten years the RESIST software has been used by teachers and students in the three New Zealand schools of architecture at; Victoria University of Wellington, The University of Auckland and Unitec Institute of Technology (Unitec); as well as at the School of Civil Engineering, University of Canterbury. Institutions paid for licences to run RESIST, and to protect the software from piracy, students could only use it on their campuses, restricting its convenience and overall usage.

The copyright to RESIST was owned by VicLink, VUW's commercialisation office, but it has agreed to waive its rights regarding the development undertaken in this project. It is unlikely that Victoria University of Wellington would have funded the proposed necessary enhancements, but even if it had, RESIST would not be widely disseminated due to the cost of purchasing a licence.

Before the completion of this project, RESIST designed buildings in accordance with the New Zealand loadings standard NZS 4203:1992. This standard was superseded between 2002 and 2004 by AS/NZS

1170 *Structural Design Actions*. It was therefore necessary to update RESIST to include all the changes incorporated in this standard, and also, since user expectations of software had increased, the time had come to update and enhance the software. Students had found RESIST attractive and easy to use, but since its modification into the Windows environment about ten years ago new approaches were needed to improve its usability and accuracy.

Methodology

The following steps were undertaken to achieve the project goals.

Step 1: Surveying users

Architecture and building science students at Unitec and VUW School of Architecture who were currently using RESIST were surveyed on how RESIST might be enhanced (see Appendix A for the survey and its full findings).

Step 2: Software programming

Software programming was then begun by Peter Wood, Computer Consultant, with advice provided by Dr. Bruce Deam of the UoC and Dr. Regan Potangaroa from Unitec. Many enhancements have been made to RESIST; the two most significant are summarised below.

The first is the provision of a new floor plan editor. Whereas users could previously only design a rectangular shaped building, now, any polygonal floor plan shape is possible. This means the form of the RESIST model can far more realistically match often-designed irregular building shapes. As well as the ability to design irregular floor plans, users can now place the seismic load-resisting elements anywhere in plan. Formerly, RESIST placed them symmetrically. This ability to model the real intended placement further reduces the difference between a real design and the RESIST model.

Secondly, in conjunction with the new floor plan editor, a rigorous approach to dealing with building torsion has been incorporated. Now the complete elastic torsion properties of the building are calculated and additional forces due to torsion included accurately. Users are warned when the configuration of their seismic resisting elements, like shear walls for example, is inadequate for torsion.

Step 3: Testing and verification

After the programming was complete, RESIST was tested in 2013 by students at VUW and a number of bugs were discovered and fixed. Another version was issued in March 2014, this time to all involved tertiary institutions. This release coincided with a presentation of the project at the New Zealand Society for Earthquake Engineering Annual Technical Conference 2014[1]. Another update to RESIST was made in July 2014 before the issue of the final version in September 2014.

[1] Charleson, A. W. and Wood, P., 2014. Enhancing collaboration between architects and structural engineers using preliminary design software. *Proceedings of the 2014 New Zealand Society for Earthquake Engineering Annual Technical Conference*, Auckland.

When the project team realised the implications of having RESIST available to users outside the tertiary sector it decided to undertake a more thorough technical validation. It was also seen necessary to produce a Verification Manual in which examples of detailed calculations of every structural system were provided. This represented a major increase in the development work we had envisaged. Although this manual will not be read by architecture students due to its highly technical nature, it may be by engineering students. It certainly provides a technical transparency to RESIST that could increase usage in the schools of engineering. This manual, as well as the less-technical User Manual, is easily accessible within the software.

Improving accessibility

Although it had always been assumed that RESIST would be hosted by the Ako Aotearoa website, for technical reasons this has not been possible and so the early releases of RESIST mentioned above were available from a Victoria University of Wellington web address.

Now the RESIST upgrade and enhancement has been completed, RESIST can be downloaded from the Ako Aotearo website (https://akoaotearoa.ac.nz/resist) and also from the host site, New Zealand Society for Earthquake Engineering (http://www.nzsee.org.nz/publications/other-publications/resist/). Because of its greater accessibility, RESIST is more easily used by students for their design projects. They now download it onto their own computers.

Project timeline

The project began in October 2011 and was scheduled for completion by July 2012. Reasons for the delay in project completion were due to an overly optimistic assessment of the time taken to introduce a desirable but optional new design approach (which proved unachievable within the extended timeframe), and a lack of progress due to fragmented part-time work on the project.

Conclusions

All the proposed technical and enhanced ease-of-use features included in the project goals have been realized. Although the project ran over the originally scheduled timeframe, RESIST has been available to tertiary students of the involved institutions since March 2014. Now it is publically available to all students via the Ako Aoteaora and New Zealand Society for Earthquake Engineering websites. In the VUW School of Architecture alone over two hundred architecture and building science students are using it currently for their design projects. There are no recommendations for future development at this stage although the project team will continue to attend to any issues users raise and update the software as often as required.

Appendix A

A report on RESIST student user surveys, October 2011

by Andrew Charleson

INTRODUCTION

In September 2011 Ako Aotearoa confirmed acceptance of the project for its Regional Project Hub Fund (RHPF). As part of the successful application, the first step of the project was to conduct surveys of students who were currently using RESIST to obtain their views on how RESIST might be enhanced.

Four classes have been surveyed using an anonymous questionnaire presented in later in this report. The classes surveyed were: Design Technology 1 from the University of Auckland, and from the Victoria University of Wellington School of Architecture, ARCI421 Integrated Technologies, ARCI312 Architectural Design Integration and BILD322 Structures.

The numbers of completed questionnaires for each course are as follows: Design Technology 1 (19), ARCI42 (17), ARCI312 (33) and BILD322 (24).

There were several question formats in the questionnaire. First, students had to indicate how many times they had used RESIST, then say whether they would run RESIST on a PC or Mac computer. Then they were given three statements and then asked to indicate the strength of their agreement or disagreement on a range from “not at all true” (1 point) to “definitely true” (9 points). Finally they were asked in two separate questions, what modifications they suggested to improve RESIST, and then any final comments.

RESULTS

The results to questions 1, 3, 4 and 5 are shown in Table 1.

Table 1. Results from questions 1, 3, 4 and 5.

Questions	**Courses**			
	DT1	322	312	421
1. How many preliminary designs have you done using RESIST?	1.26	5.16	3.05	5.14
3. RESIST is easy to use	6.00	8.20	8.00	7.43
4. RESIST is a useful tool for preliminary design	6.37	6.90	7.65	6.43
5. RESIST would benefit from some modifications	6.37	7.85	6.84	7.50

As expected, the first year students (DT1) had little experience of RESIST compared to third and fourth year students. Question 3 also shows that the first year students found RESIST more difficult to use compared to more senior students who rated the statement that “RESIST is easy to use” as mid-way between moderately and definitely true. In Question 4 students had to respond to the statement that “RESIST is a useful tool for preliminary design”. Again, the more advanced students were considerably more positive, but even the first year students considered the statement to be more than moderately true. Question 4 asked about whether RESIST would benefit from

modifications. There was widespread agreement on this topic with the more senior students more aware of how RESIST could be improved.

The results of Question 2 which asked about their preference of computer system are summarized in Table 2.

Table 2. The percentage of students who use PCs rather than Macs

Class	DT1	322	312	421
PCs users	79%	85%	65%	50%

Currently, RESIST can be run only on PCs. These results suggest that if resources allow, RESIST should be modified to be run on both PCs and Macs.

Question 6 which asked students to suggest modifications to RESIST produced some useful responses which are summarised in Table 3. In total, 129 suggestions were made. The numbers for each are listed beginning with the most frequent suggestions. Some suggestions that were not relevant to the project have been ignored.

Table 3. Summary of suggested modifications to RESIST and the numbers of students suggesting each modification.

No.	**Suggested modifications**	**No.**
1	RESIST model to be more geometrically complex and be more like real design	31
2	Allow multiple structural systems in each direction	15
3	Increase the numbers of storeys RESIST can handle	11
4	More options for materials, soils, weights etc	7
5	Be able to use RESIST on own computers	5
6	Allow partial area floor slabs and voids	4
7	More explanation of results, advice on how to improve structure, easier to read	5
8	Allow non-uniform storey heights	3
9	Provide tutorial video and generally make RESIST easier to learn and use	3
10	Allow base-isolation and damage avoidance systems	3
11	Better explanations generally and of why there are certain constraints	3
12	Provide a more user-friendly interface	2
13	Upload Revit or dwg. files	2
14	Allow larger building plan dimensions	2
15	More graphical information on how structures function	2
16	Allow different dimensions for structural elements like wall lengths	2
17	More interactive 3-D model	2
18	Asymmetrical layout of structural elements	2
19	More in Help on dealing with irregular buildings	2
20	Be able to arrange or position shear walls in plan	2
21	Allow different sized bays	1
22	Provide advice for attempting to model more than 8 storeys	1
23	Better saving features	1
24	Explain “floor width supported” better	1
25	Place model and results in same window	1
26	Notes on how to deal with curved walls	1

27	Use more diagrams in explanations	1
28	Include RC diagonal bracing	1
29	Include angled shear walls/bracing elements	1
30	Show how diaphragms work	1
31	Update timber for LVL	1
32	Be able to specify the widths of some members	1
33	Report on necessary seismic gaps to boundaries etc	1

Comment is necessary regarding the second and third ranked suggestions. These were almost entirely made by BILD322 students who had analysed existing buildings that were not only complex structurally, but in most cases far higher than the eight storeys RESIST can analyse. If the impact of this class is removed, then each those first two suggestions was made by only two non-building science students.

CONCLUSIONS

While RESIST is clearly very much valued and appreciated there is a desire from users to see modifications made to the programme. By far the most common suggestion was to enable more complex geometric forms to be modelled. This and all the other suggestions will be considered by the Project Team.

APPENDIX A (continued)

QUESTIONNAIRE ON RESIST

Introduction

A project is underway to update and enhance RESIST. As a user of RESIST we would appreciate your thoughts on the software and any suggestions you have for enhancing it. As you work through this questionnaire please bear in mind the need for a preliminary design programme like RESIST to be user-friendly. If too much input is required then the software will less widely used.

Questions

1. How many preliminary designs have you done using RESIST? .....

2. If you could run RESIST on your computer would it be on a PC or a Mac? .....

Based on the scale below please answer the following questions:

1 2 3 4 5 6 7 8 9

Not at all true Moderately true Definitely true

3. RESIST is easy to use 1 2 3 4 5 6 7 8 9

4. RESIST is a useful tool for preliminary design 1 2 3 4 5 6 7 8 9

5. RESIST would benefit from some modifications 1 2 3 4 5 6 7 8 9

6. List modifications you believe would improve RESIST

……..

……..

……..

……..

……..

7. Do you have any final comments about RESIST

……..

……..

Thank you for your participation.

Andrew Charleson, Victoria University of Wellington and Regan Potangoroa, UNITEC, Sept 2011